(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 993 008 A1

(12) EUROPEAN PATENT APPLICATION

published in accordance with Art. 158(3) EPC

(43) Date of publication:
12.04.2000 Bulletin 2000/15

(21) Application number: **98921334.3**

(22) Date of filing: **22.05.1998**

(51) Int. Cl.[7]: **H01F 27/42**, H01F 27/40

(86) International application number:
PCT/CN98/00077

(87) International publication number:
WO 98/53466 (26.11.1998 Gazette 1998/47)

(84) Designated Contracting States:
AT CH DE FI FR GB IT LI NL SE

(30) Priority: **22.05.1997 CN 97104329**

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(54) A COMBINATION APPARATUS OF DISTRIBUTION TRANSFORMER AND SWITCH

(57) A combination apparatus of a distribution transformer and switches comprising a three-phase five-leg distribution transformer, wherein the low voltage windings of the transformer are connected in Y_0 connection mode, and each phase of high voltage winding of the distribution transformer is serially connected with high voltage fuses so as to constitute a high voltage phase-arm. The three phases of high voltage phase-arms are connected in Δ connection mode. The combination apparatus of a distribution transformer and switches can be utilized either in neutral non-grounded power system, or in a power system whose neutral is grounded through arc-suppression coils or little resistors, and further it can be utilized in a power system whose neutral is directly grounded. It can be ensured that the normal power supply of the sound phases are not interfered by faulty phases.

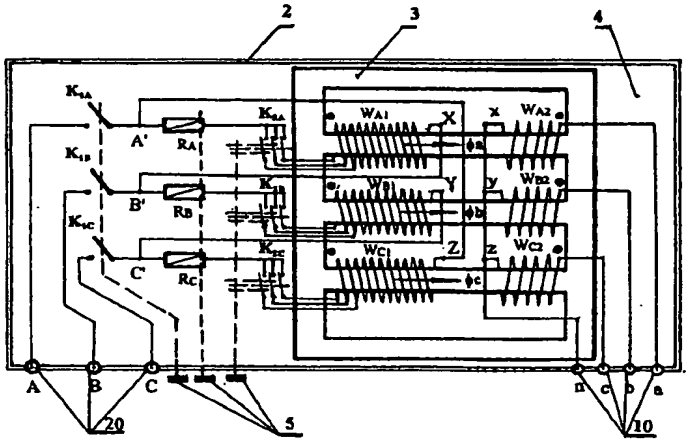

Fig.1

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Description

Technical Field of the Invention

[0001] The present invention relates to a power distribution equipment, and more particularly to a combination apparatus of a distribution transformer and switches.

Background of the Invention

[0002] At present, in China, the majority of power distribution cabinet are provided with a Δ/Y_0 connected three-phase three-leg distribution transformer, while high voltage load switches, tapping switches, high voltage fuses (or circuit breakers) etc. are installed outside the sealed enclosure of the distribution transformer. As a result, the power distribution cabinet used in China has a larger volume, occupies more land and needs more maintenance. In the United States, an integrated power distribution cabinet, in which a Y_0/Y_0 connected three-phase five-leg distribution transformer is mounted, is popularly used, wherein the main bodies of high voltage load switches, tapping switches, and high voltage fuses are installed inside the sealed enclosure of the distribution transformer. Hence, the power distribution cabinet used in the United States has a smaller volume, occupies less land and needs less maintenance. However, the integrated power distribution cabinet has a disadvantage that it can not be used in a neutral non-grounded power system. Because in a neutral non-grounded power system, whether the transformer is connected in a Y/Y_0 connection mode or in a Δ/Y_0 connection mode, interrupting of one phase of high voltage fuse will cause the other two phases to have supply voltages far higher or far lower than the rated voltages thereof. It not only impairs the quality of power supply, but also probably causes damages of the user's electric apparatus as operating under such a higher voltage or lower voltage. For the time being, in China, a solution is to trip simultaneously all three phases artificially when an one-phase fault occurs. Obviously it is not very reasonable.

Summary of the Invention

[0003] The object of the invention is to provide a combination apparatus of a distribution transformer and switches, which can be utilized bath in a neutral grounded power system and in a neutral non-grounded power system. When high voltage fuses are interrupted upon an occurrence of a phase-to-ground fault or a phase-to-phase fault, the fault-free phases can operate in a normal power supply state, only the faulty phases being in a completely open state so that the combination apparatus of a distribution transformer and switches according to the invention has three phases that are non-mutual interferential.

[0004] To this end, the combination apparatus of a distribution transformer and switches according to the invention comprises an enclosure provided with low voltage bushings and high voltage bushings, in which a three-phase five-leg distribution transformer is disposed. The low voltage windings of the three-phase five-leg distribution transformer are connected in Y_0 connection mode, and the output terminals thereof are led out of the enclosure through the low voltage bushings serving as the low voltage output terminals of the combination apparatus. The high voltage windings of the three-phase five-leg distribution transformer are connected in series with at least a set of high voltage fuses to form three phases of high voltage phase-arms, and the three phases of high voltage phase-arms are connected in Δ connection mode. The high voltage output terminals of the combination apparatus are led out of the enclosure through the high voltage bushings from the connecting points of the three phases of high voltage phase-arms.

[0005] In order to improve the interruption capacity and the ***time-current characteristics*** of the high voltage fuses, two high voltage fuses having the same performances or different performances can be connected in serial in each high voltage phase-arm.

Brief Description of the Drawings

[0006]

Fig.1 shows schematically the structure of the combination apparatus of a distribution transformer and switches according to the invention;
Fig.2a and Fig.2b schematically show the connections of two sets of high voltage phase-arms of the combination apparatus of a distribution transformer and switches according to the invention, respectively, wherein two sets of high voltage fuses are connected in different ways.

Detailed description of the Preferred Embodiments

[0007] Fig.1 shows schematically the structure of the combination apparatus of a distribution transformer and switches according to the invention. As shown in Fig.1, the combination apparatus of a distribution transformer and switches according to the invention comprises an enclosure 2 provided with low voltage bushings 10 and high voltage bushings 20, and a three-phase five-leg distribution transformer 3 disposed within the enclosure 2. The terminals of the low voltage windings W_{A2},W_{B2},W_{C2} thereof are respectively indicated by reference numerals x,a;y,b;z,c, wherein the terminals x,y,z are directly connected together each other to form a terminal n as a ground terminal. In this way, the low voltage windings W_{A2},W_{B2},W_{C2} are connected together in Y_0 connection mode. Through the low voltage bushings 10, low voltage output terminals of the combination

apparatus are led out from the terminals a,b,c and n. The incoming terminals of the high voltage windings W_{A1},W_{B1},W_{C1} of the three-phase five-leg distribution transformer 3 are respectively connected to the first terminals of a set of tapping switches K_{2A},K_{2B},K_{2C}, while the second terminals of the set of tapping switches K_{2A},K_{2B},K_{2C} are respectively connected to the first terminals of a set of high voltage fuses R_A,R_B,R_C. The second terminals A',B',C' of the set of high voltage fuses R_A,R_B,R_C are respectively connected to the outcoming terminals Z,X and Y of the high voltage windings W_{C1},W_{A1},W_{B1}. Further, The terminals A',B',C' are respectively connected to the first terminals of the high voltage load switches K_{1A},K_{1B},K_{1C}, while the second terminals A,B,C of the high voltage load switches K_{1A},K_{1B},K_{1C} are respectively led out of the enclosure 2 through the high voltage bushings 20 serving as the high voltage input terminals of the combination apparatus. The above connecting mode is so-called Δ/Y_0 connection mode, wherein Δ/Y_0-11 connection mode is preferable. The high voltage windings W_{A1},W_{B1},W_{C1}, the tapping switches K_{2A},K_{2B},K_{2C} and the high voltage fuses R_A,R_B,R_C connected respectively in serial form three phases of high voltage phase-arms A'X,B'Y,C'Z. In fact, in the three-phase five-leg distribution transformer 3, the Δ connection mode is formed by connecting in sequence the high voltage phase-arms A'X,B'Y,C'Z. Furthermore, the enclosure 2 is filled with insulation media 4 so as to ensure sufficient insulation strength.

[0008] The high voltage fuses R_A,R_B,R_C of the combination apparatus of a distribution transformer and switches according to the invention are preferably overload fuses.

[0009] Further, the manual operating mechanisms of the tapping switches K_{2A},K_{2B},K_{2C} and the high voltage load switches K_{1A},K_{1B},K_{1C} as well as the fuse elements 5 of the high voltage fuses R_A,R_B,R_C are disposed outside the enclosure 2 of the combination apparatus of a distribution transformer and switches so as to be operated and maintained conveniently.

[0010] The following discusses are focused on the operations of the combination apparatus of a distribution transformer and switches according to the invention when a fault occurs. First of all, a single phase fault is discussed. When a phase-to-ground fault occurs at the high voltage winding W_{A1} of the three-phase five-leg distribution transformer 3, the A-phase of high voltage fuse R_A is interrupted, and thus the high voltage winding W_{A1} loses its exciting current, while the high voltage windings W_{B1},W_{C1} of the sound phases B and C are still fed with normal rated voltages from the three-phase power supply, wherein the corresponding fluxes ϕb and ϕc form a loop respectively through the two side legs. Since the low voltage winding W_{A2} of the phase A is connected with a load impedance, the synthetic flux of the fluxes ϕb and ϕc can hardly flow back through the leg of phase A, and hence the induction voltage on the low voltage winding W_{A2} is very small. Therefore, under the condition of the fuse R_A being interrupted, the phase A-to-ground voltage Ua0 output from the low voltage side of the three-phase four-line power system is approximately zero, while the sound phases B and C can still output rated voltages.

[0011] Hereinafter, a two-phase fault is discussed. When a fault occurs on the high voltage windings W_{A1} and W_{B1} of the three-phase five-leg distribution transformer, the high voltage fuses R_A and R_B of the phases A and B are interrupted, and thus the high voltage windings W_{A1} and W_{B1} lose the exciting current thereof, while the high voltage winding W_{C1} of the sound phase C is still fed with normal rated voltages train the three-phase power supply, wherein the corresponding flux ϕC forms a loop through the two side legs. Since the low voltage windings W_{A2} and W_{B2} of the phases A and B are connected with load impedance, the flux ϕc can hardly flow back through the legs of phases A and B, and hence the induction voltage on the low voltage windings W_{A2} and W_{B2} of the faulty phases are very small. Therefore, under the condition of the fuses R_A and R_B of the phases A and B being interrupted, the phase A-to-ground voltage Ua0 and the phase B-to-ground voltage Ub0 output from the low voltage side of the three-phase four-line power system are approximately zero, while the sound phase C can still output a rated voltage.

[0012] Of course, if necessary, two or more sets of high voltage fuses can be connected in series in the high voltage phase-arms of the combination apparatus of a distribution transformer and switches according to the invention. Fig. 2a and Fig.2b schematically show two different connections between three phases of high voltage phase-arms of the combination apparatus of a distribution transformer and switches according to the invention, in which two sets of high voltage fuses are connected in series. In Fig.2a, in the high voltage phase-arm of phase A, two high voltage fuses R_{A1} and R_{A2} in serial are connected at the incoming terminal of the high voltage winding W_{A1}. Similarly, in the high voltage phase-arms of phases B and C, two high voltage fuses in serial R_{B1} ,R_{B2} and R_{C1}, R_{C2} are connected respectively at the incoming terminals of the high voltage windings W_{B1} and W_{C1}. The two high voltage fuses connected in series in each high voltage phase-arm may be the same or different. Preferably, the high voltage fuses R_{A1}, R_{B1}, R_{C1} are current-limiting fuses and the high voltage fuses R_{A2}, R_{B2}, R_{C2} are overload fuses having better inverse time-current characteristics.

[0013] The connection relations of the three phases of high voltage phase-arms of the combination apparatus of a distribution transformer and switches as shown in Fig. 2b are similar to those in Fig. 2a. The difference only lies in that the set of high voltage fuses R_{A1}, R_{B1}, R_{C1} are respectively connected in serial at the incoming terminals of the high voltage windings W_{A1},W_{B1},W_{C1}, while the other set of high voltage fuses R_{A2}, R_{B2}, R_{C2} are respectively connected in serial at the outcoming

terminals of the high voltage windings W_{A1},W_{B1},W_{C1}.

[0014] The combination apparatuses of a distribution transformer and switches provided with the high voltage phase-arms as shown in Fig.2a or Fig.2b have operation states similar to the above. Further descriptions are omitted.

Industrial Applicability

[0015] The combination apparatus of a distribution transformer and switches according to the invention can be utilized in either a neutral non-grounded power system or a power system whose neutral is grounded through arc-suppression coils or little resistors, and further it can be utilized in a power system whose neutral is directly grounded. Because the high voltage fuses are serially connected in the three phases of high voltage phase-arms connected in Δ connection mode, it can be ensured that the normal power supply of the sound phases are not interfered by faulty phases so that the reliability of the power supply can be improved.

Claims

1. A combination apparatus of a distribution transformer and switches, comprising an enclosure (2) provided with low voltage bushings (10) and high voltage bushings (20), and a three-phase five-leg distribution transformer (3) disposed in said enclosure (2), wherein the low voltage windings (W_{A2},W_{B2},W_{C2}) of said three-phase five-leg distribution transformer (3) are connected in Y_0 connection mode, and the output terminals thereof are led out of said enclosure (2) through said low voltage bushings (10) serving as the low voltage output terminals of said combination apparatus;

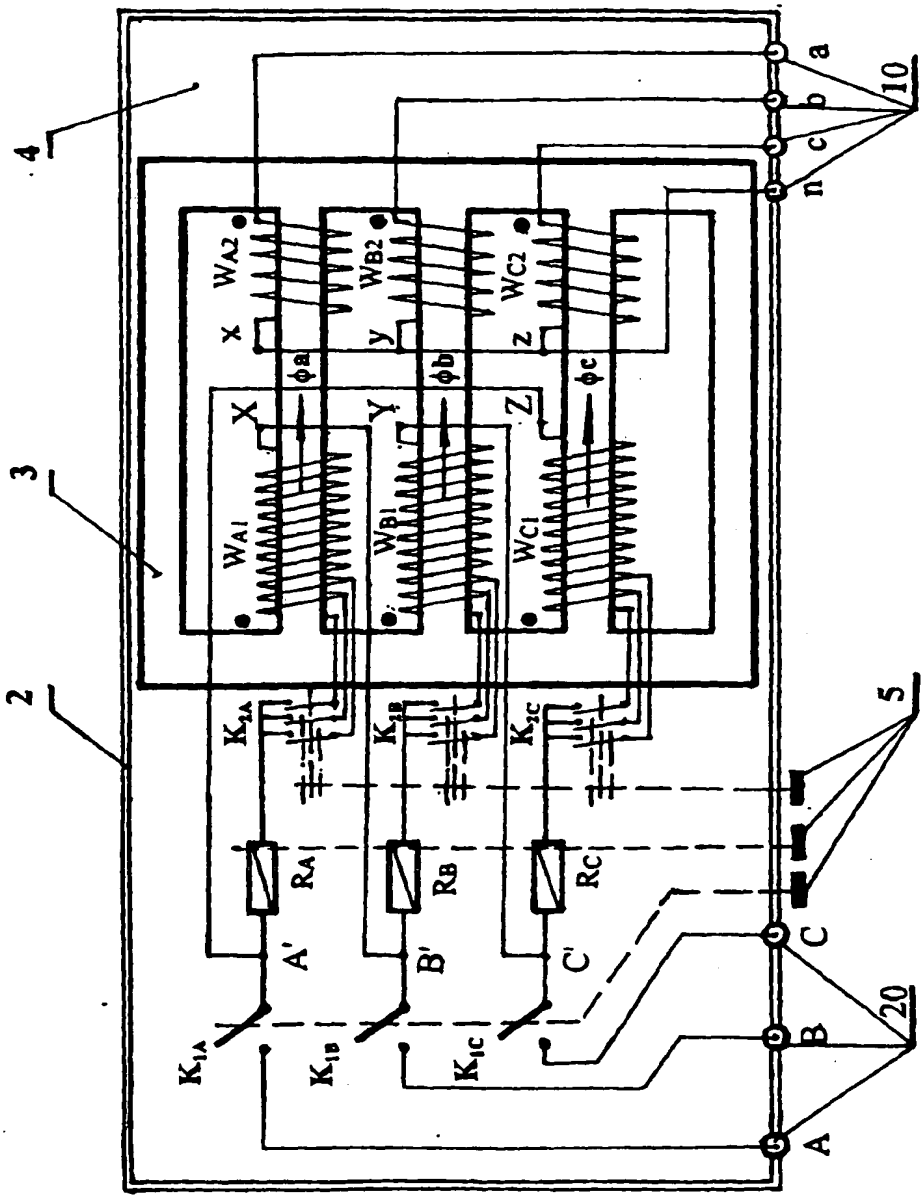
   characterized in that high voltage windings (W_{A1},W_{B1},W_{C1}) of said three-phase five-leg distribution transformer (3) are connected in series with at least a set of high voltage fuses (R_A,R_{A1},R_{A2}; R_B,R_{B1},R_{B2} ;R_C,R_{C1},R_{C2}) so as to form three phases of high voltage phase-arms, and said high voltage phase-arms are connected in Δ connection mode, the high voltage input terminals of said combination apparatus being led out of said enclosure (2) through said high voltage bushings (20) from the connecting points of said three phases of high voltage phase-arms.

2. A combination apparatus of a distribution transformer and switches as claimed in claim 1, characterized in that said high voltage fuses are overload fuses.

3. A combination apparatus of a distribution transformer and switches as claimed in claim 1, characterized in that said high voltage fuses are current-limiting fuses.

4. A combination apparatus of a distribution transformer and switches as claimed in claim 2, characterized in that a set of current-limiting fuses are further serially connected in said three phases of high voltage phase-arms.

5. A combination apparatus of a distribution transformer and switches as claimed in any of claims 1-4, characterized in that said high voltage phase-arms are connected in Δ/Y_0-11 connection mode.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W_{C2}
W_{A1}
W_{B1}
W_{C1}
ϕa
ϕb
ϕc
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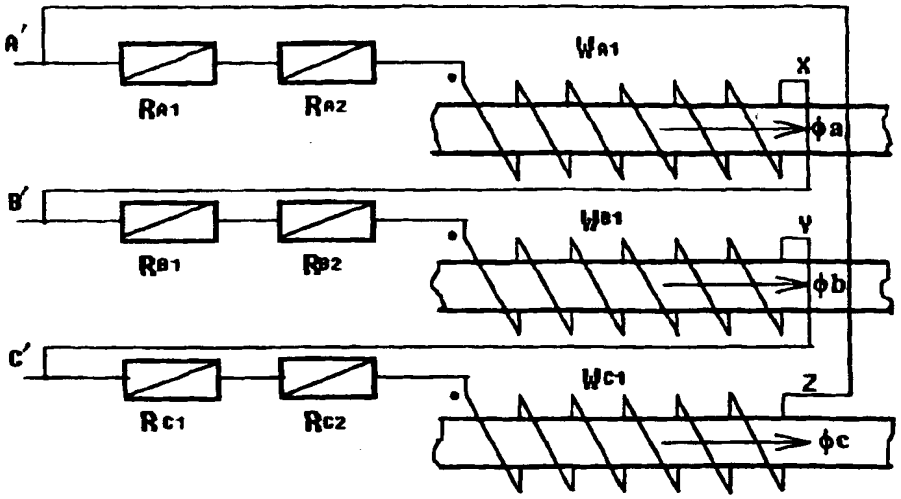
R_A
R_B
R_C

Fig.1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B'
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RA2
RB1
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RC1
RC2
WA1
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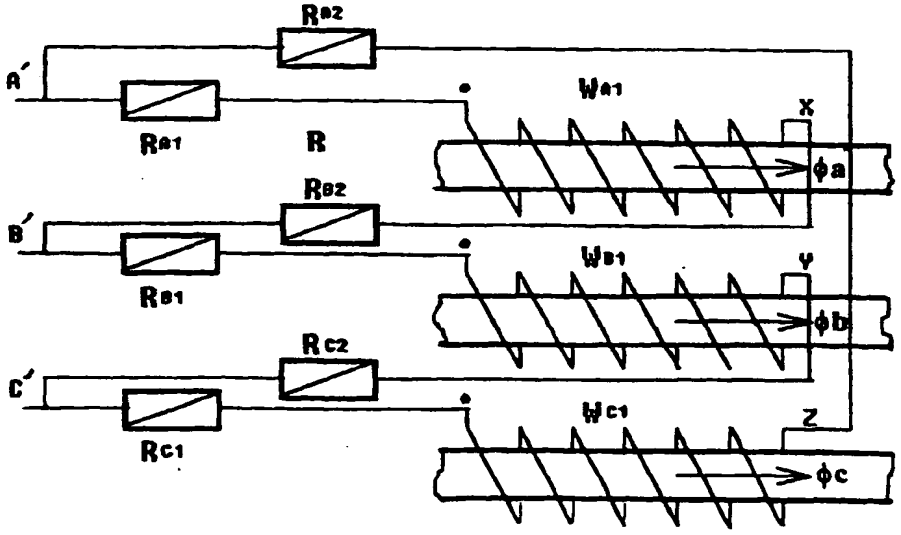
Fig.2a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B'
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RB1
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WA1
WB1
WC1
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φb
φc

Fig.2b

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN 98/00077

A. CLASSIFICATION OF SUBJECT MATTER

IPC⁶ H01F 27/42, 27/40

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC⁶ H01F 27/42, 27/40

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US—A—2,198,489(Westinghouse Electric & Manufacturing Company), 23. April. 1940(23. 04. 40) See page 6 left-column line 3—line 44; figure 6,12	1—5
A	EP—A—0024934(Olympus Optical Co., Ltd.) 11. March. 1981(11. 03. 81) See page 1 line 25—line 33; figure 1	1
A	JP—A—61008645(Kabushiki kaisha Takenaka komuten) 15. March. 1986(15. 03. 86) See column 2 line 14—column 3 line 14; figure 1	1

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20. Aug. 1998(20. 08. 98)	10 SEP 1998 (10.09.98)
Name and mailing address of the ISA/ Chinese Patent Office, 6 Xitucheng Rd. Jimen Bridge, Haidian District, 100088 Beijing, China Facsimile No. (86—10)62019451	Authorized officer Zhang Peng Telephone No. (86—10)62093823

Form PCT/ISA/210(second sheet)(July 1992)

INTERNATIONAL SEARCH REPORT
Information patent family members

International application No.
PCT/CN 98/00077

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2,198,489	40. 04. 23		
EP 0024934	81. 03. 11	JP 56035402	81. 04. 08
JP 61008645	86. 03. 15	Non	

Form PCT/ISA/210(patent family annex)(July 1992)